FINE-SCALE ACOUSTIC BOTTOM REVERBERATION

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LONG-TERM GOALS

The long-term goal of this project is to relate macro-scale bottom reverberation and clutter descriptions to micro-scale scattering mechanisms and develop from this a simplified scattering law for ready application to operational sonars.

OBJECTIVES

Identify fundamental bottom scattering mechanisms by comparison of micro- and macro-scale scattering models to reverberation data and test scattering functional forms for validity of fit.

APPROACH

This project compares measured acoustic data taken near the Mid-Atlantic Ridge (MAR) with model predictions of reverberation, in order to identify fundamental scattering mechanisms. Previous studies of reverberation in the MAR had identified a Lambert-like macro-scale scattering function for areas where the bathymetry was measured to a resolution of 200x200 m. However, the angular form taken by the data in question may not be exactly of the Lambert form of sine squared of the grazing angle and may, in some angular regions, be closer to sine to the first power. The seafloor in the region investigated is generally rugged and strongly reflective on the higher sloped faces that appear to be responsible for the strong returns that dominate the backscatter. The regions responsible for the stronger returns are likely to be thinly sedimented, if sedimented at all. Weaker scattering from flatter, deeply sedimented regions appear to be subdued by scattering from rugged regions off the beam axis and from multiple bounces from scattering originating in rugged regions.

We have developed techniques that concentrate primarily on roughness scattering at two scales. The larger scale features are modeled by a macro-scale scattering function in which the details of scattering are suppressed in favor of some simple angular functional form. Two-dimensional large-scale features (200m x 200 m planes) are considered by calculating a *local* incidence-backscatter angle with micro-scale roughness (microroughness) introducing a *diffuseness* in the *forward* scatter direction. This is consistence with our hypothesis that properly oriented, high-slope facets dominate the backscatter. We recently completed several publications that demonstrate the validity of our two-scale roughness model and our means of selecting the partition between the scales. The model that characterizes this form of scattering is the Rough Facet Model (RFM) which is embedded in the Bistatic Scattering Strength Model (BISSM)

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For detailed analyses at the micro-scale level we employ a modeling architecture we first developed in the early 1970s, the Stochastic Helmholtz-Kirchhoff (SHK) scattering model. Normally, HK models are not valid in the backscatter direction; however, they can accurately predict scatter consistent with our hypothesis that scattering is dominated by rough facets oriented so that the forward scatter direction is in the backward direction. In this effort, higher resolution bathymetry measurements (5x5 m) taken in the same region of the MAR, supplemented with superimposed, simulated micro-scale roughness (0.5x0.5 m) is the basis for applying the SHK. To test this hypothesis directly, the Wedge Assemblage (WA) model, specifically for backscattering, will also be applied to measured/simulated bathymetry. We believe that for the region of the MAR under study, it is critical to consider all scale of roughness and to use 2-D geomorphology and 3-D acoustic simulations. The roughness at important scales is not isotropic, which is what most 2-D acoustic models applied to 1-D geomorphology assume.

WORK COMPLETED

All acoustic models required for this work are complete and published or pending publication, and the rough surface simulations are nearly complete. A new modeling capability (RFM) has been described in the literature. Reverberation data has been analyzed from an area where the bathymetry was measured to a resolution of 200x200 m and a Lambert-like scattering mechanism was identified. We have demonstrated that Lamberts law and variations to it are theoretically possible and likely, and probably no single, simple function describes the full angular range.

RESULTS

Recent analyses has identified a more complex scattering functional form than the sine-squared Lambert form, but the results suggest that form varies with angle from sine to the first power to second or higher powers.

IMPACT/APPLICATIONS

An improved understanding of scattering mechanisms and how they translate into simple operational models is being provided by this work.

TRANSITIONS

This work can transition to other ONR and NRL projects on bottom scattering and ultimately to reverberation modeling for active sonars.

RELATED PROJECTS

This project is related to the Bottom Scattering and Reverberation part of the Acoustic Reverberation and Scattering Research Program that has just been completed and to the newly established DRI in Shallow-Water Bottom Scattering.

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